Set 20: Lewis Structures Part II

Skill 20.01: Draw Lewis structures for molecules that undergo resonance
Skill 20.02: Draw Lewis structures for molecules whose central atom does not follow the octet rule

Skill 20.01: Draw Lewis structures for molecules that undergo resonance

Skill 120.01 Concepts

When doing Lewis dot structures you are often confronted with a situation where several structures are correct. The only difference between the structures is the arrangement of the electrons. Consider the following example for NO_2^-,

Step 1: Count the valence electrons

N=5, 2 x O=12, 1- charge=1 the total valence electrons is 5+12+1 = 18

Step 2: Arrange the atoms into a skeleton

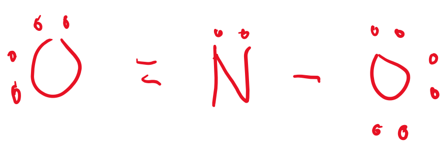
Subtract the electrons used to make the skeleton from the valence electrons counted in step 1,

18-4 = 14

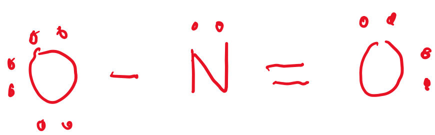
Step 3: Complete the octets for all the atoms using the remaining electrons counted in step 2. Save the central atom for last.

Each line indicates 2 electrons and may be used instead of dots. Notice that once all the electrons are placed around the molecule, the N still does not have an octet.

Step 4: Make a double bond in order to satisfy N's octet



OR



Notice that although but structures are slightly different, they are both correct; the only difference is the arrangement in the electrons. Valid dot diagrams that differ from one another only in the arrangement of their electrons are called **resonance structures**. Experiments have shown that in such structures, the double actually resonates between the possible locations.

Skill 20.01 Problem 1

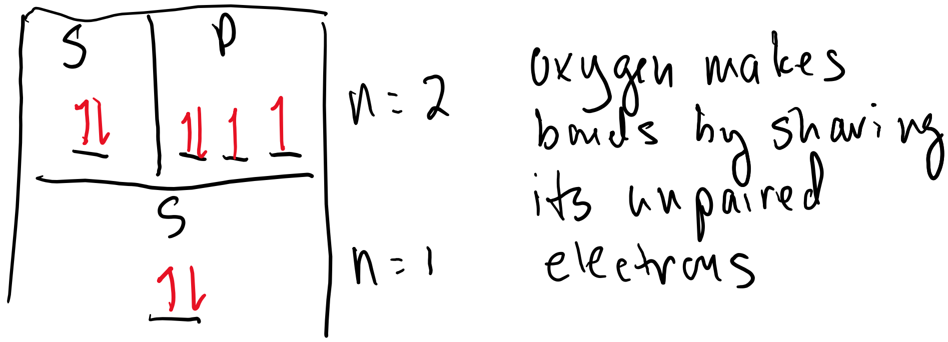
Draw Lewis structures for the following molecules:
(a) O_3
(b) SO_2
(c) CO_3^{2-}
(d) ClO_4^-
(e) Which of the above molecules undergo "resonance"? How do you know?

Skill 20.02: Draw Lewis structures for molecules whose central atom does not follow the octet rule

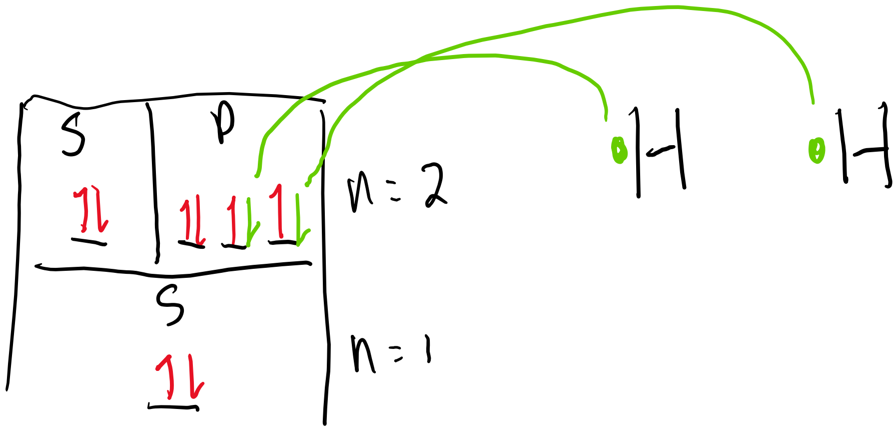
Skill 20.02 Concepts

So far, all the molecules you have drawn have had central atoms which follow the octet rule. That is, the central atom is satisfied with 8 electrons. There are many situations however in which the central may have less than 8, or more than 8. Before, we get into examples of exceptions, let's review how covalent bonds are formed in the first place. Let's consider the formation of the H_2O molecule.

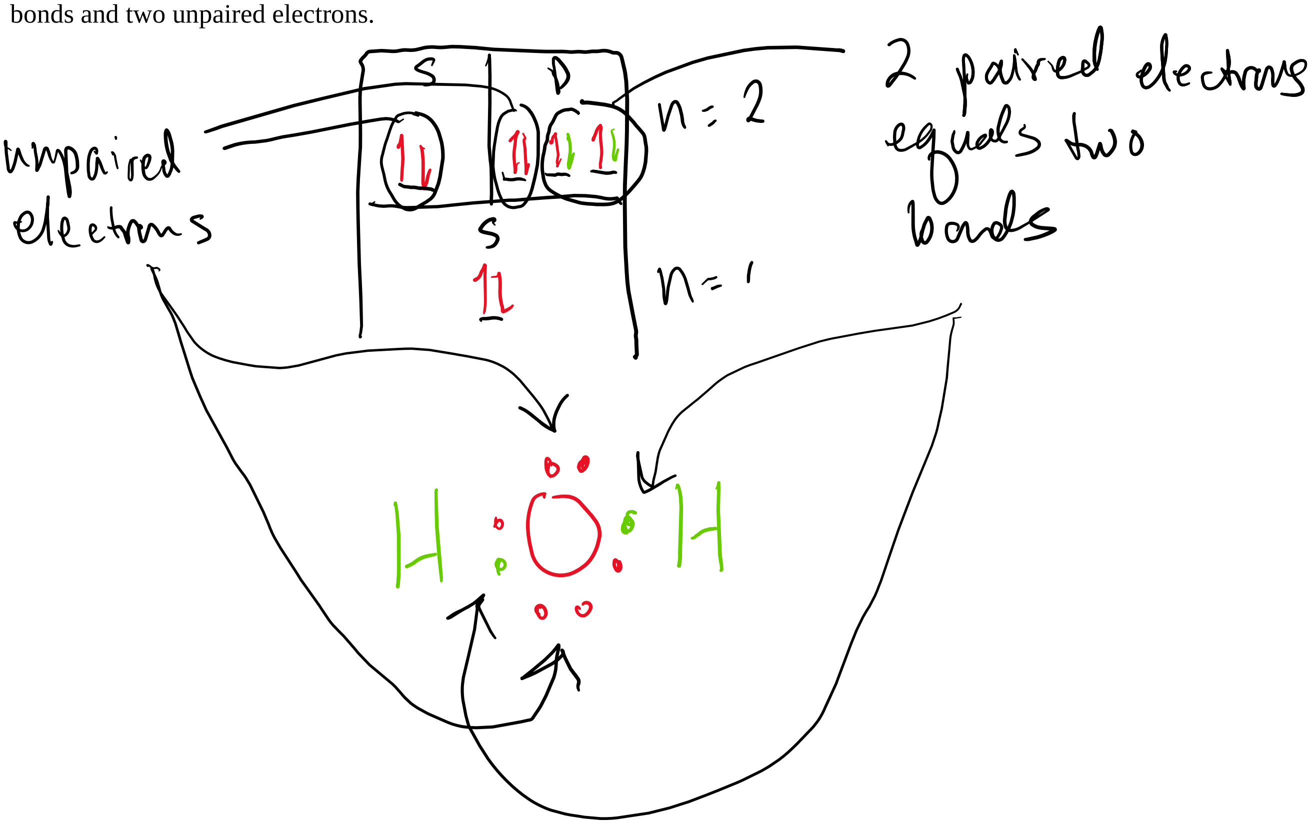
According to our previous discussions, oxygen has 6 outer electrons and therefore "likes" to form 2 bonds to have 8 outer electrons. Let's look at this another way. Consider the following arrangement for the oxygen's electrons,



We can see from the arrangement above that oxygen needs two more electrons to fill it's outer most "p" room. By sharing its unpaired electrons, oxygen can achieve this configuration,



We can see from the above diagram that a stable configuration for oxygen is one which oxygen has two bonds and two unpaired electrons.

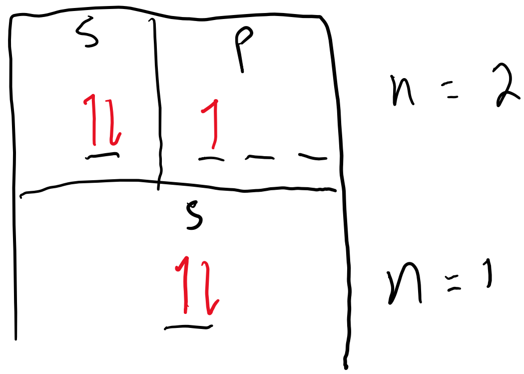


The final structure above illustrates the connection between bonding and non-bonding electrons.

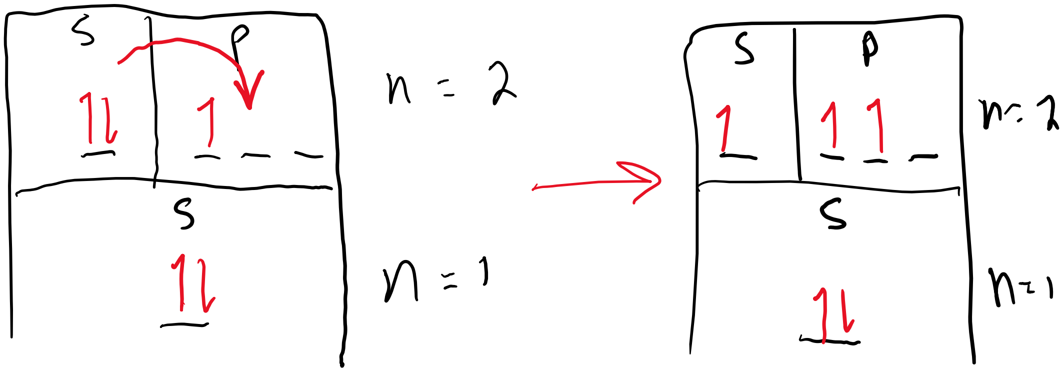
Now let's consider another example,

Boron

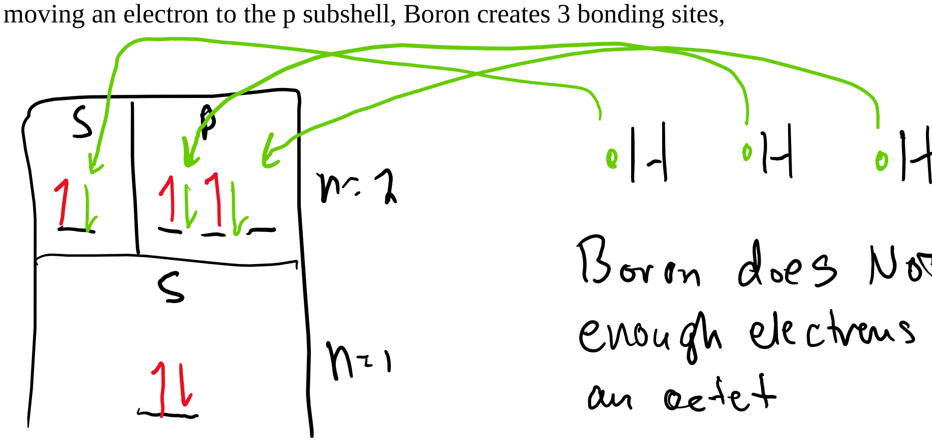
The arrangement of Boron's electrons are as follows.



Now, according to the arrangement above, Boron only has 1 unpaired electron, so it appears that it my only be able to make 1 bond. But, the electrons on the outer most level can move to make room for more bonds,

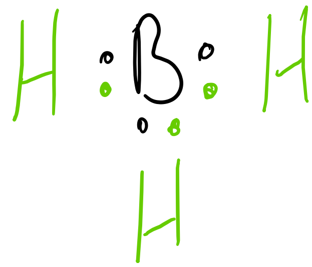


By moving an electron to the p subshell, Boron creates 3 bonding sites,



Boron does NOT have enough electrons to make an octet

The final structure for BH_3 is therefore,

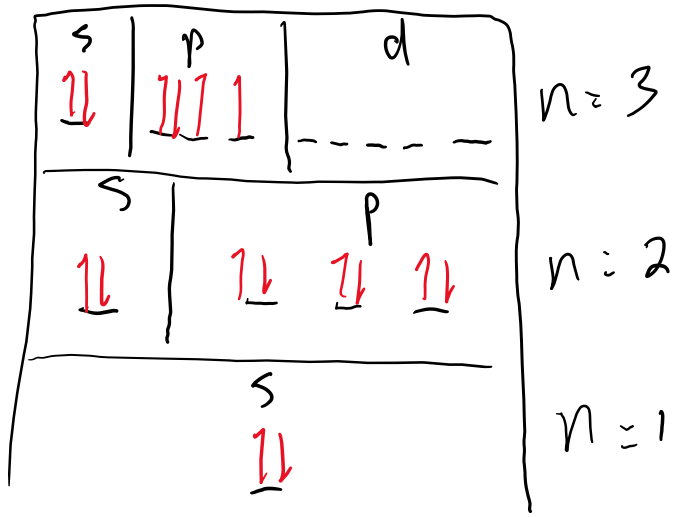


Notice in the above structure, Boron, does NOT have an octet because it simply does not have electrons.

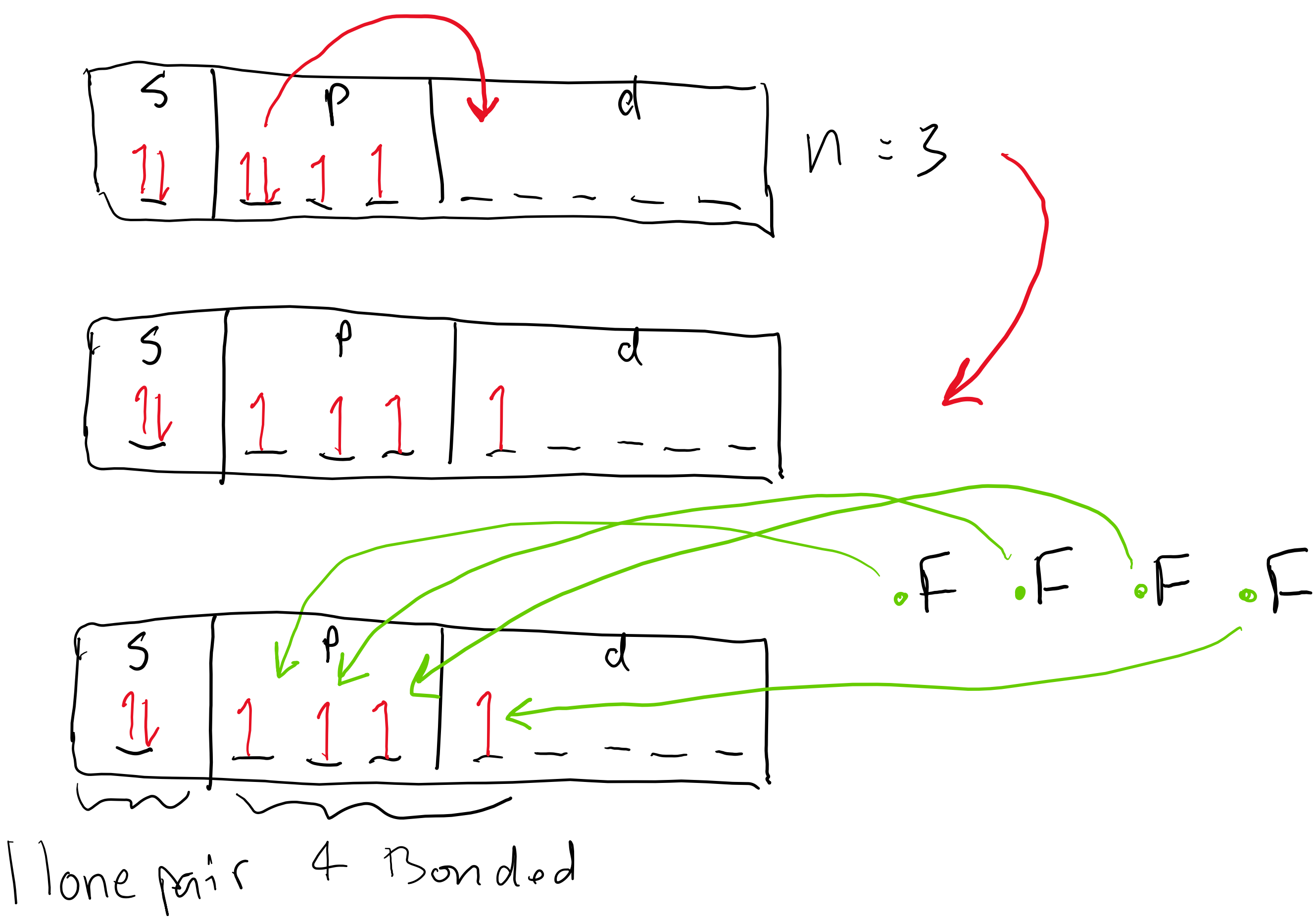
Skill 20.02 Problem 1

Beryllium can only form two bonds. Explain why using principles of electron structure.
Draw the Lewis structure for BeF_2.

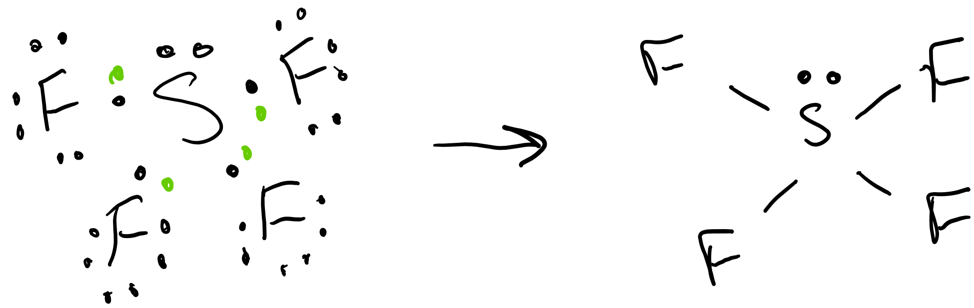
Now, let's consider what happens with sulfur. Sulfur has the following electron arrangement,



Because sulfur's outer electrons are on the 3rd main energy level, they have the "d" subshell to expand into. Because of this fact, sulfur can accommodate more electrons that what is predicted by the octet rule. Consider the bonding process for SF_4 for example. Below we will only consider the outer most electrons in our diagram,



The final structure for SF_4 is therefore,



While we could have arrived at this same structure by going through the Lewis drawing steps described previously, it is useful to have justification as to why such structures can occur in the first place.

Skill 20.02 Problem 2

Sulfur can form up to 6 bonds. Explain why using principles of electron structure.
Draw the Lewis structure for SF_6.

Skill 20.02 Problem 3

Draw the following Lewis structures:	
PCl_5	XeF_4
ICl_4^-	I_3^-